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COMPUTERIZED MATERIAL PROPERTY DATA INFORMATION SYSTEM

PLASTICS TECHNICAL EVALUATION CENTER,
DOVER, NEW JERSEY

JUNE 1976

PLASTEC NOTE N31

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PLASTEC

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PLASTICS TECHNICAL EVALUATION CENTER

PICATINNY ARSENAL
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The program has been structured to computerize both plastics and metals property data, in support of engineering, manufacturing and procurement

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COMPUTERIZED MATERIAL PROPERTY DATA INFORMATION SYSTEM

by

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JUNE 1976

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A program to computerize material property data was established by an ad-hoc Army group. It was initially supported by Picatinny's Computer Aided Design Engineering (CAD-E) activity, through which the information system was determined to be feasible. This report describes the proposed system operation by remote and on site access modes planned throughout the Army.

The program has been structured to computerize both plastics and metals property data, in support of engineering, manufacturing and procurement activities, using common software and hardware. Although many commercial, material property data programs have been developed none contain the unique features to be incorporated, i.e., remote access by display terminals, comprehensive engineering oriented data and the most centralized source of plastics and metals data. The report primarily addresses plastics technology with limited discussion of the metals integration.

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INTRODUCTION

OBJECTIVE

The overall objective of this program is to enable the rapid access to material property data in support of Army engineering, manufacturing, and procurement activities. A more unique feature is to enable the assessment of materials through the use of computer technology by the interactive application of material property criteria. A secondary goal of this program is to provide the most comprehensive, military oriented material property data base for plastic, a first of its kind.

BACKGROUND

The initial impetus for this program developed within the Materials Engineering Division at Picatinny Arsenal, when it was recognized that the techniques for plastic material analysis and assessment could be significantly improved through the use of computer technology. This led to the consideration of the methodology and subsequent demonstration of computer approaches to more effective design. The initial Picatinny effort (Ref. 1) led to the consideration of a more comprehensive overall Army oriented program to consider selection routines for metals as well as plastics.

The integration with metals resulted when it became known that a comparable task was underway at the Ground Equipment and Materials Directorate (MICOM) at Redstone Arsenal. Although the mode of computer access differed from that planned for plastics, it was felt that each effort would complement the other. With the long term objectives directed at use of comparable hardware and software, new requirements were also established which would satisfy the needs of both programs. Since MICOM's role was end item or user oriented, the responsibility of such a metals property data bank effort was believed to be best served by AMMRC, who has current monitorship of metals property data activities.

An ad hoc CAD-E committee consisting of AMMRC, ARMCOM (Picatinny Arsenal) and MICOM then formulated an Army wide plan in 1974 under a CAD-E project title for the selection of materials. The committee action established the need to develop a sophisticated, yet simplified computerized system which could be interactively accessed by all Army engineering segments. It was established that two data base files, one each for plastics and metals, were needed with control to be exercised from within the Army.

This report is intended to present the rationale which led to the current program and how it will meet the needs of the Army and other DoD activities. The overall system concept will be described to include discussion of computer hardware and software. Also included is the

planned location of the plastic and metal data files and how Army facilities could interface with these files.

The main thrust of this report, however, will be related to the materials properties and assessment effort related to plastics. Details of the proposed data management system, property data file and the modes of access will also be presented with their relationship with the concurrent metals data program.

The program since its inception has been directed solely at initial material selection. It, however, has been reoriented to be more encompassing, in that it will now be directed at property data as influenced by the processing techniques. This will result in a data information system useful to manufacturing design functions, procurement and in initial material selection.

DISCUSSION

The assessment of plastic materials for the wide variety of military applications has been of concern by the materials engineering staff at Picatinny Arsenal for the last decade. It was concluded that the proper use of a plastic material or "polymer" for an application currently requires an astute evaluation on the part of knowledgeable materials technologists. This is basically necessitated by (1) the lack of or the inadequacy of current engineering property data to enable an effective evaluation and (2) the lack of materials knowledge by designers not totally familiar with plastic material behavior.

Plastic material property data is grossly lacking. This problem is being further complicated by the continued number of new, commercially available materials. The point is being approached whereby the cataloguing and storage of the available data is cumbersome. It is imperative that computerization be undertaken to return some reason to data availability and presentation.

Due to the large number of applications within the government, it is also impractical to provide the necessary skilled plastics personnel to support all the development efforts. Technical support by the material suppliers is a viable but diminishing (because of costs) alternate although their approach at most times is biased by company affiliation. Even though industrial personnel were available, their support does generally lack a military orientation toward the design environment and product assurance functions. Thus, a need exists for a means whereby the many product development efforts can be more effectively conducted objectively, and by those lacking the plastics materials background. This necessitates that the data be presented in the most simplified form to enable complete understanding of material response. This simplicity coupled with an appropriate logic scheme, will enable those not initiated in plastic or computer technology to satisfactorily perform materials assessments.

In view of the above two needs, it becomes necessary to turn to the computer as the means of promoting effective plastic usage. This implies that a data bank can be structured to provide property data for the large number of materials which are commercially available. It should be noted that there is no such source of information readily available throughout the industry. This task is large, but can be achieved through government and industrial participation. The second facet of a computerized effort is to provide a unique mode of operation whereby materials can be screened for evaluation as specified by appropriate input criteria. This too presents a challenge in its implementation.

It was proposed to develop a technique whereby any engineer or designer can interface with the computer to assess an appropriate plastic

material(s) to meet his requirements. To accomplish this, it is planned to incorporate interactive graphics routines which will provide the necessary design logic and data presentations to enable ease of operation by those not skilled in plastics or computer technology. The scope of this effort is novel and is practical. In support of all Army commodity commands, it will result in substantial cost reduction and savings.

The initial efforts funded under Computer Aided Design-Engineering (CAD-E) were initiated through the Plastics Technical Evaluation Center (PLASTEC) at Picatinny, with technical support provided from the Materials Engineering Division's plastics applications staff. This direction was established since it was projected that the results would have wide range Army use and that PLASTEC would be a natural outlet for the capability developed.

The first such type of computerized program was developed under CAD-E funding and has subsequently been made available through PLASTEC. Designated as "COMPAT", Figure 1, the program contains information on the COMPATibility of plastics with energetic materials (explosives, propellants and pyrotechnics). It can be remotely accessed and currently has a number of subscribers. It was made available on a fee basis, which was intended to provide funds for program update and maintenance. The program truly demonstrates the concept of computer effectiveness and remote access. It represents only a minute portion of the overall system.

The value of the computer for metal material selection is also quite apparent. Currently no existing data source for metals can be effectively or efficiently accessed by Army personnel for assessment purposes. Data from the established materials information centers are available, but are time consuming to obtain and not adaptable to local computer activities. Thus, most military design activities still rely on design manuals or handbooks for data. A basic data bank for metals for internal Army use will aid in improved interactive material assessment.

The main thrust of the material assessment program is not to develop a system to contain all existing "design data" for materials, but rather to provide the fundamental "property data" for initial material selection and for conducting other comparative material assessments. For end item use, normal engineering practice requires prototype evaluation, cost assessments and further material characterization for the specific application. This implies that further information will be required through other information sources and material suppliers. Although not all encompassing, the proposed material property data banks will contain a substantial amount of data to fulfill most basic engineering needs.

Further discussion of the overall system and some specifics are contained in the following paragraphs. These are intended to be general presentations, to be supplemented later in time with specific engineering definition of all program aspects.

SYSTEM CONCEPT

The materials property data information system is essentially intended to aid Army personnel in materials technology by making available engineering data. The access modes to computerized data are highly dependent on the sophistication of the engineer/user in regard to design analysis, material technology and computer technology. In view of this, the system must provide capability for varied user backgrounds. In addition, the state of the art of design for metals and for plastics varies widely which necessitates that two independent data banks be established, with possible future integration as program technology progresses. The generalized approach is schematically illustrated in Figure 2.

Interactive access with the material property data banks will be controlled through a data management system (DMS). User input and output will be controlled by use of a terminal which will allow direct access or interactive use through a preprogrammed front end or other analysis programs.

For users skilled in material technology direct access can be used to obtain materials information to meet their needs. For those not so trained, a preprogrammed front end will provide the necessary logic, tutorially. For the very sophisticated, engineering analysis routines can be made to directly perform iterative operations for material selection. All these program options imply a sophisticated and comprehensive data management system.

To implement the Army wide program, responsibilities were assigned to the activities according to their area of mission responsibility and expertise. When the system is completed each group will participate in an Army wide educational seminar to make the technology available to all engineering segments.

The three participants and functions are summarized as follows:

AMMRC-	Establishment and maintenance of the metals data bank, the basis of which will be derived from existing data sources under current monitorship.
ARMCOM- (Picatinny Arsenal)	Establishment and maintenance of an original plastics data bank and the development of a preprogrammed front end for tutorial material selection.
MICOM-	Development of the computer technology for integrating engineering analysis program with the metals property data bank, to achieve material selection through iterative computer operations.

The intent of this program is to achieve maximum benefits with a minimum investment. Thus, the prime direction in connection with hardware is to assure system development around the CDC and IBM computers, since they are employed by most of the prospective Army users. Initially, the computer facilities will be structured around existing hardware at Redstone and Picatinny. Both installations employ CDC computers and Tektronix display terminals, which provide the user with unlimited versatility. Adaptability of other terminal types for remote access will be addressed accordingly. The only remaining item is a versatile data management system to achieve program objectives. This cost thus represents the only major investment connected with computer services. A DMS which will fulfill the needs of both the plastic and metal efforts was the ultimate objective.

Upon completion of the system, which includes the appropriate software and property data, the operation will be initially structured as follows (Figure 3): The plastic file will be located at Picatinny and the metal file at both Watertown and Redstone. All other Army installations with terminal facilities will then be capable of interacting with each of the data files by telephone link. If the remote access capability becomes inconvenient or costly, a system file can be installed at moderate cost, with data update support provided by the monitoring agency. Those installations (only three are known) which utilize other than CDC or IBM computers are restricted to remote access, unless they wish to incur software conversion costs.

The direction at Picatinny in addition to establishing the plastic data bank, will be directed at material assessment by the non-plastics types. This will be accomplished through a preprogrammed front end routine usable through display or tube type terminals. The necessary logic will lead one through material assessment and provide necessary advisement in the materials selected for use.

The establishment of a metals data bank by AMMRC will entail the specification of properties for the data bank and in procuring same. Information will be obtained as much as possible through existing sources; i.e., metal information centers and other government organizations.

The techniques connected with integration of existing programs used in engineering design and the material selection module will be developed by MICOM. It is planned to utilize the output parameters of the analysis routines which specify the design criteria to be inputed into the data management system. The DMS would then allow iterative operations between the data bank and the design routine to select one or more suitable materials. This very sophisticated approach to design will also be supplemented by direct user access of the data file for final materials assessment.

When this basic three year program is completed, it will provide the Army with a unique capability, useful for a wide variety of purposes and needs. Use by the other services is anticipated and appropriate action will be taken to facilitate their needs.

DATA MANAGEMENT SYSTEM

The key to an effective material selection program is the data management system (DMS). The system represented in Figure 2 must provide the capability to store information (data bank) and then enable retrieval and manipulation. Many such commercial systems have been developed but vary widely in their content and capability. Many of the developed programs are proprietary in nature or structured for company use only.

The search for an effective data management system for plastics was initiated under a Lehigh contract (Ref. 2). The intent of the Lehigh survey was to determine (1) the state of the art for plastic material selection programs and (2) which programs were potentially adaptable for the effort. This assessment was based on criteria established for the Picatinny directed program. The general conclusion drawn by the contractor was that a new data base must be created for selection of plastics. None of the existing plastic data systems were capable of use without major modification.

During the plastic data base investigations, the GE&M Directorate at MICOM was independently investigating data base systems to be used in their metals material selection program. They also determined that existing metal property data bases were inadequate to suit their needs and thus initiated an in-house effort to develop a selection program. The subsequent integration of the metals effort then led to the consideration of systems adaptable for both projects with the intent of commonality in both software and hardware, thus reducing overall cost to the Army.

The development of a new data management system, hopefully to fulfill the needs of both programs, was initiated and included three possibilities, that is

- Writing of a new program in the scientific Fortran language
- Modification of an existing Government owned program
- Modification or purchase of a new data base management system structured for material selection.

Each of these was explored with hardware for the integrated program centered on the facilities at both Picatinny and Redstone Arsenals. This orientation established the Control Data Corporation's CDC 6500 or CDC 6600 computers and the Tektronix T-4002 and T-4014

display terminals as the basic hardware. Since most remaining Army design facilities have IBM computers, software adaptability to these facilities was also considered. This approach necessitates primary funding for software only. In other words the availability of a software program and data will result in a usable system.

The result of this continued DMS evaluation, conducted jointly by the Picatinny's PLASTEC and Management Information Services Directorate (MISD), concluded that the most economical approach would be the purchase of an existing DMS. Such a system, however, must be structured to perform the material selection and contain a variety of features needed to meet overall program directions. Of the known programs, the Data Retrieval System (DRS) evaluated in the Lehigh contract (Ref. 2) was further reviewed. It was determined to be the most viable program to pursue due to its inherent simplicity and versatility. It is structured for material selection and contains a wide variety of unique features.

Contacts were also made with the Computer Software Management and Information Center (COSMIC) and the New York office of Government Services Administration to determine if any usable systems were available. The replies were negative. A review of an unpublished report (Ref. 3), which surveyed existing computer facilities, also indicated only specialized and company oriented programs existed, generally with limited capability.

The two most prominent metal data centers were contacted to determine what system aspects might be useful in the current program. From discussions with key personnel, it is still apparent that the existing data base management systems would require major modification to suit the Army program needs. Metal data transformation itself would, however, be possible and is contemplated for the proposed Army system. An NBS survey (Ref. 4) also provided a good summary of metal data sources, and also brings out the depth of metals information technology. No available DMS was apparent from this review to suit all program needs.

The idea of writing a new program for plastics material selection at Picatinny was discarded in view of the cost that would be incurred. An alternative was to consider the program under development at the GE&M Directorate at MICOM. The MICOM program review was initiated, but subsequently discontinued when the MICOM group examined the DRS system and determined it to be suitable for their needs. As a result of the decision by MICOM, a direction was established whereby software would now be shared for both plastics and metals material selection, further reducing overall program costs.

The modification of an existing government purchased software program was also considered for use. The one program available at Picatinny Arsenal was System 2000, as purchased from the MRI Systems

Corporation. Programming was initiated and elementary trials were made to assess its suitability. Following continued review it was determined that it too was not the best approach to take. The available DRS system would be, again, a more economical system to pursue. System 2000 was also reviewed by MICOM personnel and considered to be an unacceptable direction.

The net result of the search for a DMS to meet the broad Army requirements was the decision to convert the Data Retrieval System (DRS) developed by the Aeronautical Research Associates of Princeton (ARAP) to the CDC 6000 Series computers. Since DRS is currently written for IBM, adaptability to the total Army needs can be easily accomplished. The system will meet all the Army needs and provides a simple user capability to encourage other segments to avail themselves of computer technology.

MATERIAL PROPERTY DATA

The availability of property data for plastics has not changed significantly over the last ten years, in that, reliance on material suppliers to provide data still prevails. With the product needs known, a search is made of available plastics data based on the experience of the engineer. Material data sheets, design handbooks, technical journals and known reports are manually searched, hopefully to obtain sufficient data for an effective comparison of the many plastic materials. This approach becomes frustrating in that a complete material property picture is never achieved.

Many literature sources contain comparative property data; but they are grossly inadequate for design purposes. For many military applications the unique environments are not generally considered. An example of this uniqueness can be seen in artillery projectiles where the rate of loading is important, that is, the dynamics during gun firing. The effect of this variable on mechanical properties is not adequately reported. Compatibility or chemical resistance of plastic materials with explosives and propellants is another unique area where little data is available from commercial sources.

To say that this problem is unique to the military would be an error. The identical problem is experienced by industry. To make the point succinctly, there is an overall lack of proper, comprehensive property design data necessary to suit the needs of the military and industry. Many industrial and military organizations are attempting to develop effective data and have made some progress, but it is by far limited in scope. This means that product development and product improvement activities remain time consuming and are not as thoroughly assessed as they should be.

The need for computerization of property data is also evident by the sheer number of plastic materials which are commercially available.

This is because the property changes are a function of the manufacturing process and the combinations of discrete compositions. Material suppliers continually introduce changes in compositions through the use of stabilizers or other additives, which in essence results in changes in material response.

The solution to this problem lies in the effective use of computer technology. With the cooperation of government and industry, a program of this magnitude can become a practical reality. For this military oriented program the materials of interest consist of metals, polymers and ceramics, Figure 4. Polymers are further divided into adhesives and coatings, plastics and elastomers. For plastics, the method of manufacture will influence the basic material such that each may be handled as a distinct material, that is, its properties are a function of the process. An elementary example is an injection molded polystyrene which is structurally quite different from a foam version, even though both are manufactured by the injection molding process.

When plastic material combinations are considered, the picture becomes more complex as generally illustrated in Figure 5. There are an endless number of combinations of thermoplastics and thermosets when reinforcements and fillers are incorporated into the basic resin. The story is still not complete because of other possible variations as alloying, use of flexibilizers or other chemicals, introduced to modify one property or another. No mention has been made of that class of material known as "composites" or "advanced composites". These materials have been identified or categorized under the bag/layup/laminated category and present another complex facet of plastic material technology. Only through computerization can a more rational picture be made for the endless number of materials.

Although the above discussion relative to the molding process and materials variations presents a complex materials picture, reason will be used in the assessment for the military oriented data bank. It is planned to restrict the initial effort to the high volume use plastics, those most commonly found in product applications. Other materials and forms will be added accordingly as the system is developed. It is also planned to provide computer capacity for up to 4000 distinct plastic materials. This capacity is considered more than sufficient for the next 10-15 years.

Engineering property data for design has been one aspect emphasized by the Materials Engineering Division at Picatinny. In spite of the efforts of this Division's personnel but mostly by those of the many industrial, engineering oriented personnel, little change is apparent in manufacturer's and in the open literature. Those companies that have promoted good design data continue to do so, whereas the remainder follow the same old path. This is ironic in that the mechanism for generating good data, via the ASTM standards, is well developed but just not implemented properly. Furthermore, it is believed that the bulk of what is desired for this program is in existence but just not made available for commercial use.

When the task of computerizing data was undertaken, one paramount restraint imposed on the system was that only useful property data for product engineering purposes would be included. The basis for this was that nonoriented design data was not only useless and misused, but that it would also unnecessarily consume computer storage space. The remaining property data with commercial relevancy can be readily grouped as that necessary for processing and that for quality control, assurance or standards. These represent two independent files which should be created, the latter of which will be considered in this program.

This project also recognizes current industrial practices and the complexity of data generation. The ASTM procedures were evaluated and were found to generally contain all the necessary elements for proper data generation. ASTM data which is used for characterizing plastic material properties are basically an extension of the testing technology for metals. This is a natural development in testing if one recognizes that plastics are different and adjusts test methods and interpretations accordingly. These methods represent the only standardized source of data generation for plastics within this country. Property data will therefore conform to that as specified by ASTM. For those areas where the state of the art is not fully developed as for the high rate of loading and impact modes, appropriate improvements will, naturally, be suggested.

Another main point which was addressed is, "What is the right material property data for design?" This question may become controversial depending on the definition of design and the viewpoints as expressed by various designers. An attempt to answer this question was undertaken in a previous technical report (Ref. 1). The responses received were encouraging and constructive. The most comprehensive comments were provided by Army installations. From these comments and as a result of consultation with selected technical design personnel in industry, a list of property data formats will be established as the basis for this program. Additions, alterations or improvements will be made as necessary during program implementation to facilitate the presentations.

Metal property data acquisition does not present any significant problem, since data has been compiled at many metals oriented information sources, including computerized data formats. Abstraction of particular data formats for use in this system will result in availability on an interactive basis. The metals property data formats also pose no problems for this program since the properties are suitable in conventional design equations.

SYSTEM FEASIBILITY

To further assess the feasibility of a system as described herein, a pilot study effort was conducted under contract by ARAP. The intent was to demonstrate a working system developed around plastics data in the desired formats. This small effort, Ref. 5, was successful in demonstrating the capability of the DRS program to effectively store, manipulate and output desired information based on user input criteria.

The versatility of DRS as a suitable data management system was also evidenced through various presentations to Army technical personnel, such that its features are highly desired for other areas of interest. Conversion of the DRS program to the CDC 6000 Series computers would greatly aid many engineering activities.

This feasibility study coupled with the experience of the COMPAT program has provided the basis for extremely high success in achieving the goals of this program. It also appears that this direction will result in a highly cost effective program, i.e., maximum results with minimum expenditure of time and funds.

CONCLUSION

The use of computer technology has been determined to be necessary for the rapid access of property data for materials in use by the Army. The concept of remote access to data has been effectively demonstrated by the Picatinny-developed COMPAT program and also under contract.

An ad hoc committee, established under CAD-E funding, consolidated independent Army efforts for metals and plastic materials selection with the goal of standardization of use of a final system. The committee further expanded the effort with emphasis on manufacturing processes and their influence on material properties. This program will greatly assist all engineering functions in materials assessments and also those activities connected with procurement of materials.

A system has been planned whereby all Army segments can rapidly access data either remotely or on site, to provide a novel capability in materials assessments. This will be accomplished through the adaptation of an existing commercial data management system to Army CDC and IBM computers. Planned interactive operations with terminals employing display scopes will greatly enhance the effectiveness of all materials assessments.

Two independent data banks, one each for metals and plastics, will be established. The plastic data bank will be extremely comprehensive, military oriented material property data, a unique feature and the first of its kind to be developed.

PROGRAM DESCRIPTION

COMPAT is a specialized computer program developed to provide rapid access to data describing the influence of propellants and explosives on the behavior of polymers. It is the only known central source of this type information, obtained from tests conducted at Picatinny Arsenal and a wide assortment of data published in the open literature.

COMPAT's extensive data for plastics and elastomers is programmed on the Picatinny CDC 6600 computer. Currently 2500 system combinations are on file with updates made as data is received.

COMPAT is now available to all government agencies and industry on a fee basis. The service fee is intended to guarantee the updating of the system with the latest and most accurate information.

COMPAT can save your organization time and dollars by avoiding costly, manual literature searches. The information obtained is complete, describing conflicting data and report references for further detailed analysis.

SERVICES OFFERED

Data access can be obtained on an unlimited basis by annual subscription or for those with an occasional need, a single inquiry service is provided.

An annual subscription to *COMPAT* will provide the user with unlimited availability to the computer data file. The subscription includes the option to access the computer directly via conventional computer teletype/telephone link. For direct access, a user's guide (with code) will be provided describing the capabilities and simplicity of the system. Direct access provides immediate answers via the teletype printout.

For those annual subscribers without the capability of direct data access, specialists at Picatinny will provide the answers by telephone and/or mail as you desire. The annual subscription service regardless of use made is available at a charge of $375.

For single inquiries, *COMPAT* is available for a fee of $75 per inquiry: Searches are made by contacting a specialist at Picatinny, who will provide your answer. Single inquiry fees are payable at the time of the inquiry.

Figure 1. COMPAT Services Brochure

DETACH HERE

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Picatinny Arsenal, Dover, N.J. 07801

Gentlemen:

☐ Enter my subscription to *COMPAT*. Please forward my user guide and code.
- ☐ Payment inclosed (Checks payable to the Treasurer of the United States).
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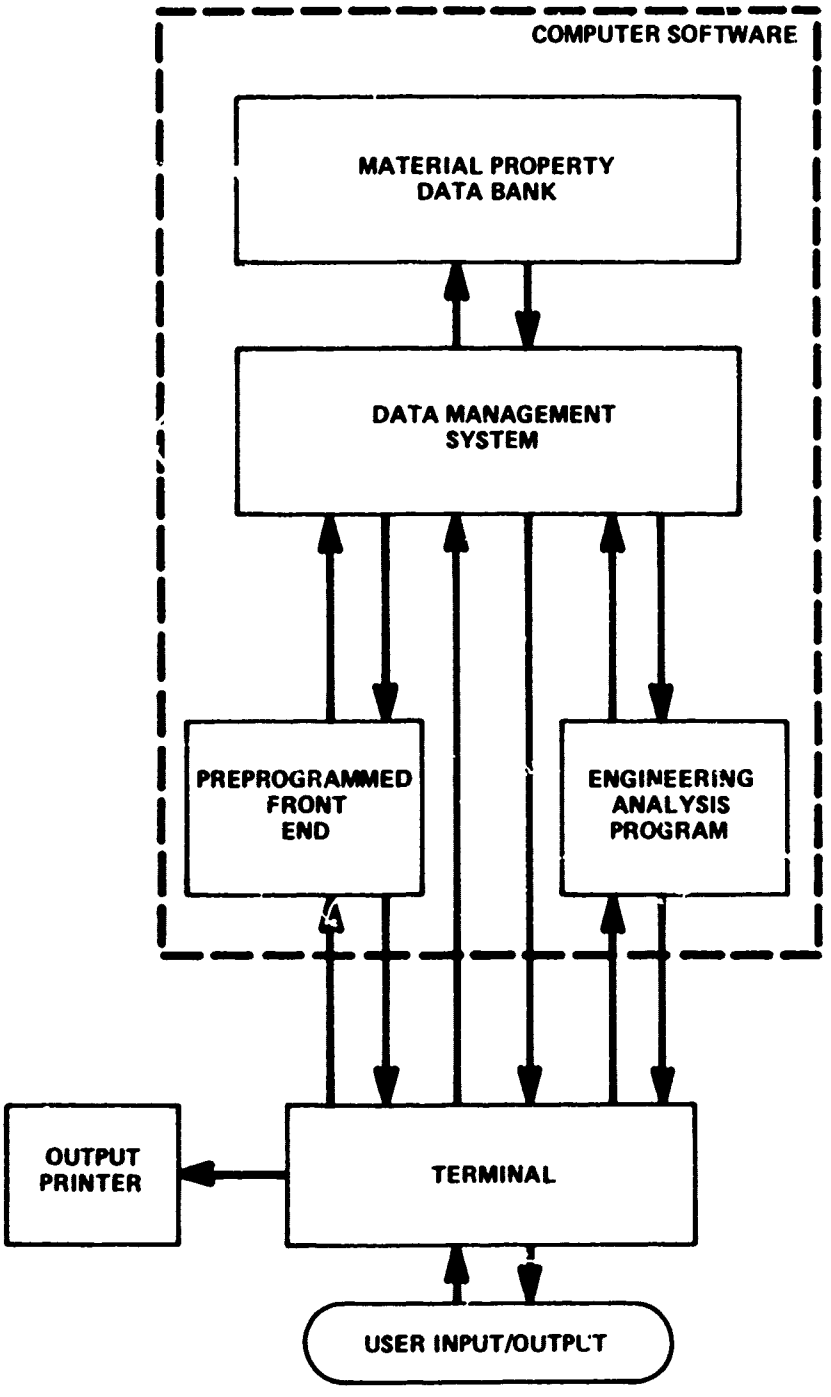

Figure 2. Schematic, Data Retrieval Concept

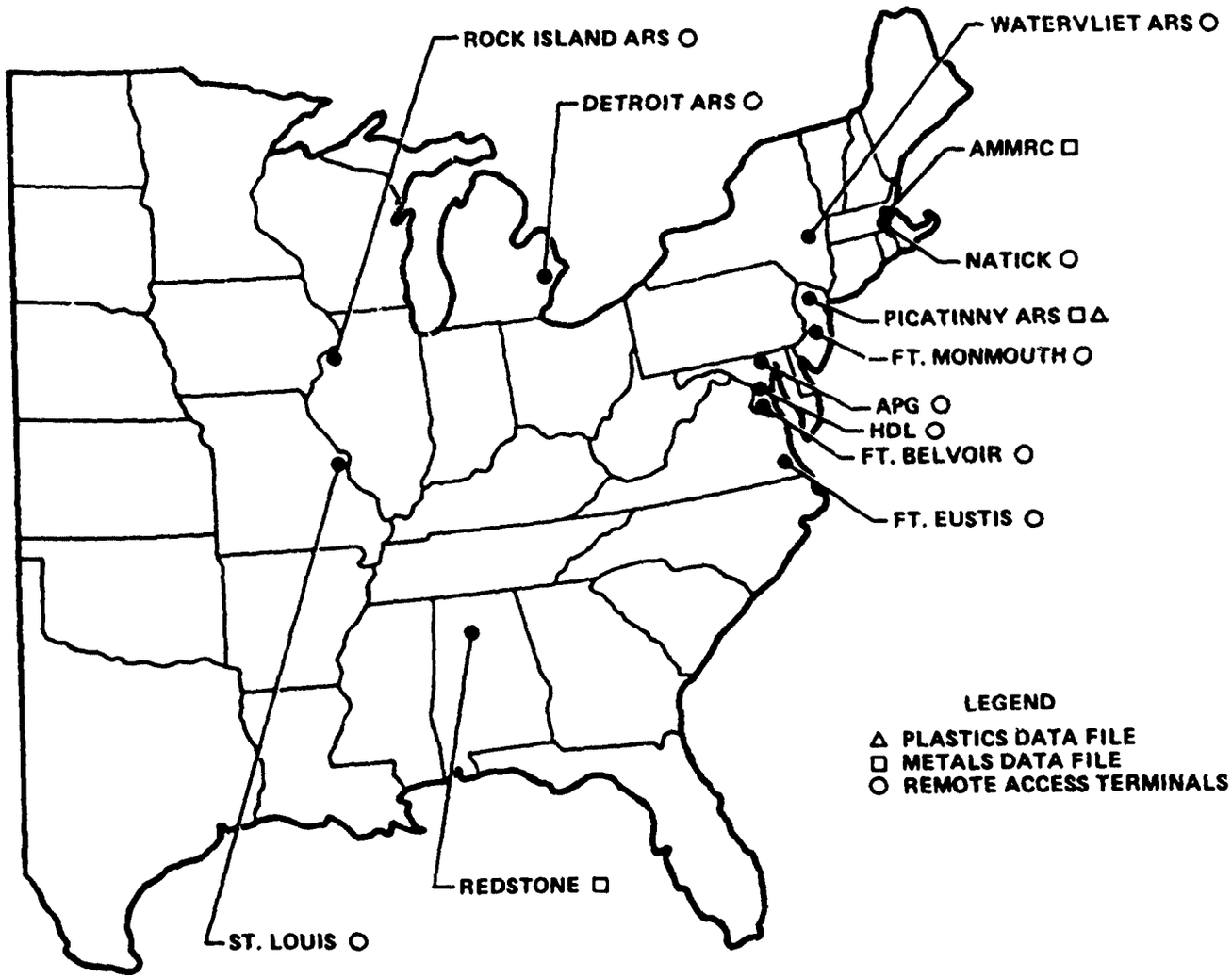

Figure 3. Computerized Information System Network

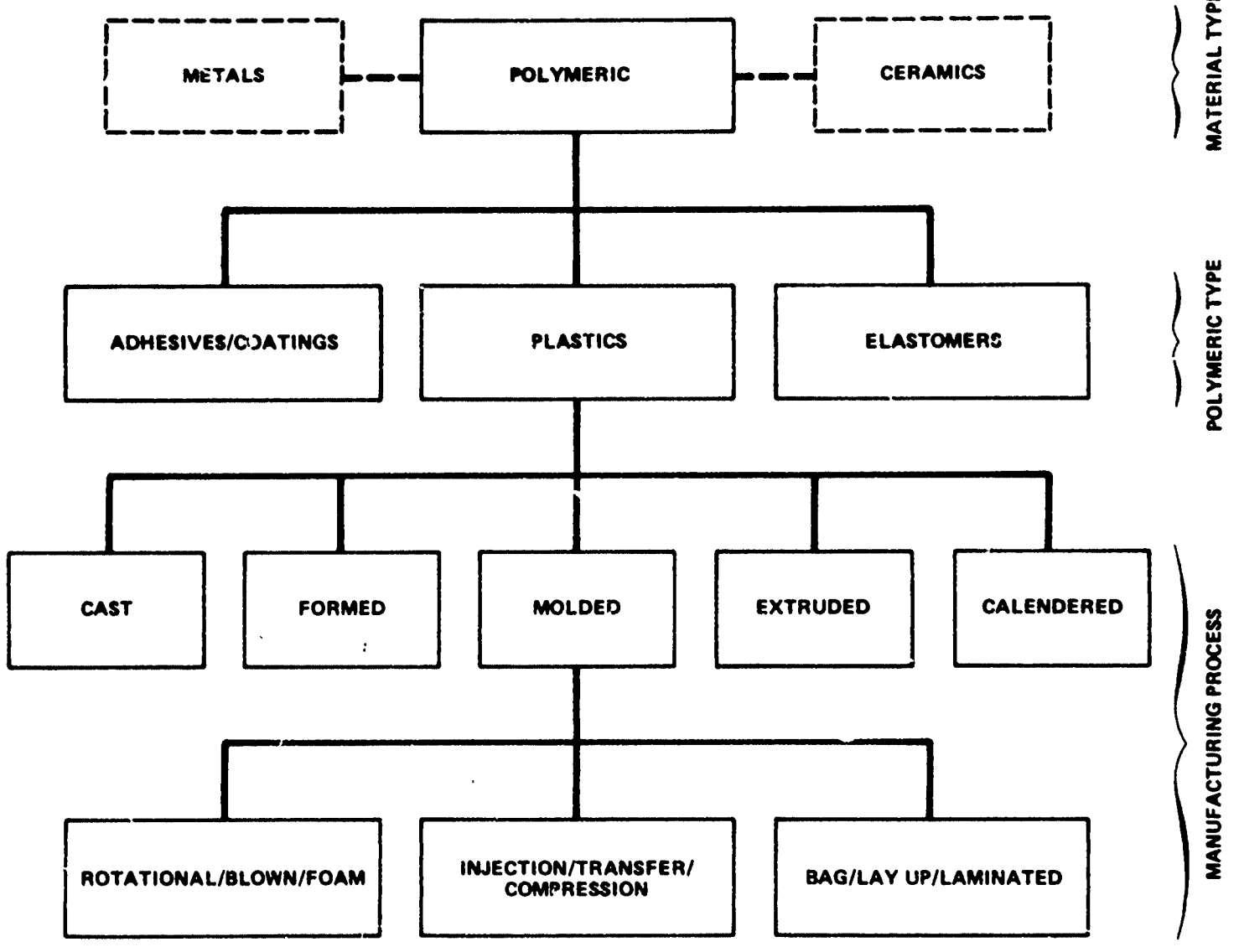

Figure 4. Plastic Material Categorization

THERMOPLASTICS	THERMOSETS	REINFORCEMENT/FILLERS
Acrylic (PMMA)	Epoxy	Glass spheres, solid
Cellulose acetate	Melamine-formaldehyde	Glass spheres, hollow
Cellulose acetate-butyrate	Phenol-formaldehyde	Fiberglass, short
Cellulose nitrate	Phenol-furfural	Fiberglass, long
Ethyl cellulose	Polyester	Asbestos fiber
Polyacetal	Polyurethane	Talc
Polyamide (nylon 6, 6/6, 6/10, 11, 6/12, 12)	Urea-formaldehyde	
Polycarbonate	Diallyl phthalate	
Polyester		
Polyethylene (LD, MD, HD)		
Polyphenylene oxide		
Polypropylene		
Polystyrene (ABS, SAN)		
Polysulfone		
Polytetrafluoroethylene		
Polytrifluorochlorethylene		
Polyvinyl acetate		
Polyvinyl alcohol		
Polyvinyl butyral		
Polyvinyl chloride		
Polyvinylidene chloride		

Figure 5. Polymeric Materials

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